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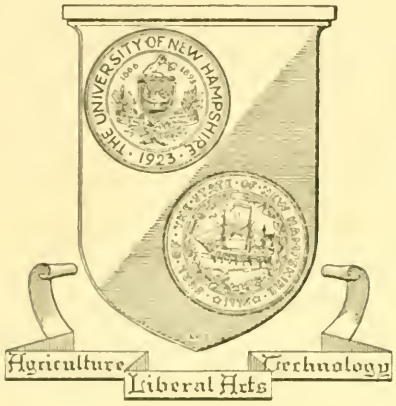

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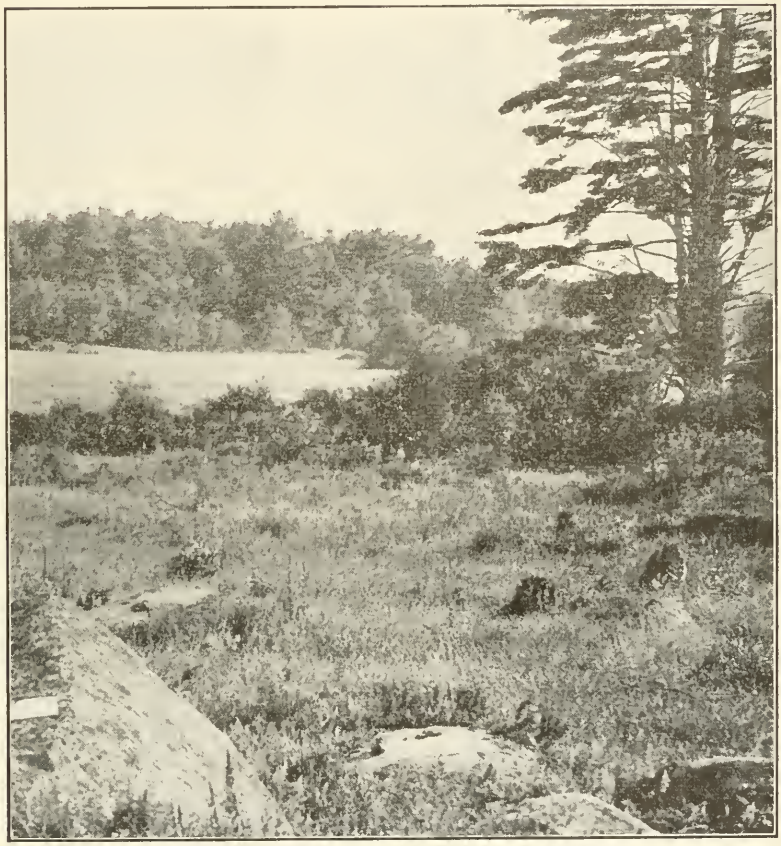
Bulletin 326 June, 1940

STUDIES OF PASTURE MANAGEMENT



by Max F. Abell

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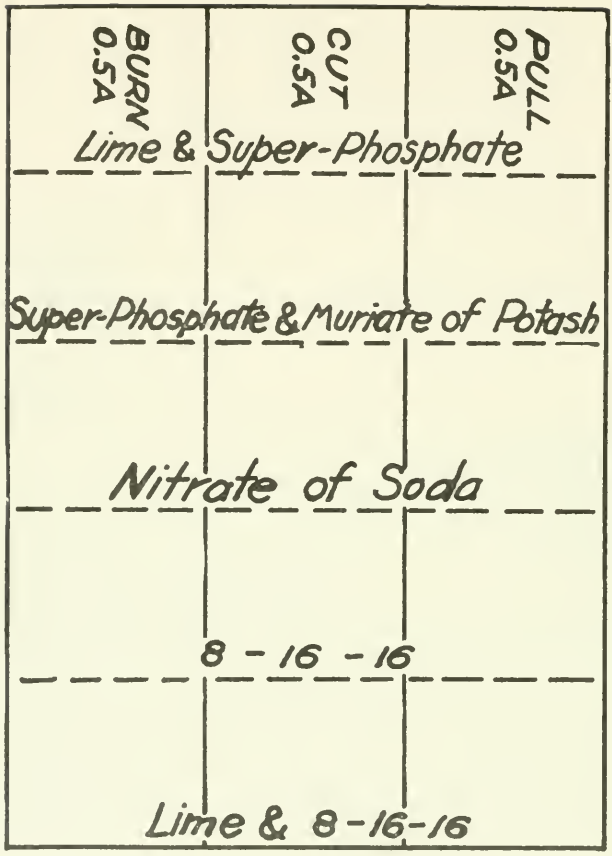

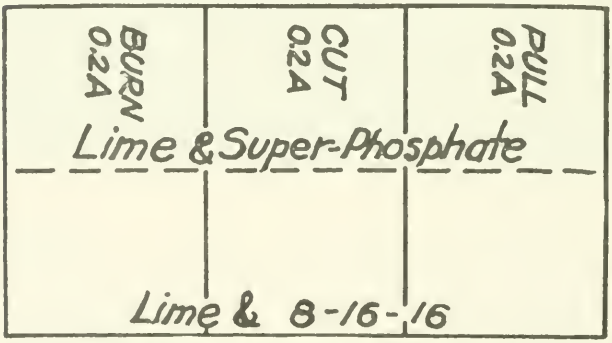

Fig 1. Arrangement of pasture plots for special treatments, 1937-38.

Studies of Pasture Management

By Max F. Abell

DURING THE SPRING of 1935 a pasture study was begun by a survey of pasture conditions on 256 farms scattered throughout the state. This preliminary survey was made to determine some of the pasture problems facing the dairy industry and to determine some of the best methods to be used for their solution. As pasture is the cheapest form of roughage, it appeared desirable to develop a pasture improvement program that would furnish this roughage most cheaply.

An analysis of the data obtained indicated that considerably more pasture would be needed to maintain the present dairy population than could be furnished by the present open pasture even if improved by fertilizing, or brought to maximum production in other ways. There appeared to be a need for clearing and improving some of the old pasture that had been permitted to grow up to brush. From the survey, data on methods commonly used in getting rid of brush on pastures were obtained as well as data on the permanence of such brush removal under different treatments. As a result, the second phase of this study was inaugurated in the spring of 1937 to determine:

a. Best methods and costs of removing brush.
b. Effect of method of removal on brush reproduction in later seasons.
c. Effect of different fertilizer treatments in checking brush reproduction and on improvement in pasture herbage.
d. Effect of grazing on checking brush reproduction.
e. Change in soil conditions as result of fertilizer treatment.
f. Change in pasture herbage as result of brush removal, fertilizing, and grazing.

Good pasture is fundamental to economical production of dairy products. Census data indicate that "as goes the pasture so goes the dairy industry." A decline in pasture productivity has been followed by a decline in agriculture, or a shift to some other type of agriculture not dependent upon pasture.

In New Hampshire this decline has been accompanied by a more or less gradual return to forest growth. A large part of this shift from pasture to brush and finally to forest has occurred on poor soils of rough topography, or in the more remote areas less suited to agriculture. A few farms in these areas have persisted because of better soils, more aggressive farmers, or, frequently, because of a special outlet for milk.

For a time in New Hampshire production continued with cheap grain and relatively cheap labor, but eventually lack of pasture has lessened the carrying capacity of the farms to the point where they will no longer provide the income necessary to carry expanded social

costs and a satisfactory standard of living. This has been especially true with those farms not on improved roads.

Many of the soils of the state are derived from granites, which usually produce gravelly or sandy soils with a low moisture holding capacity. The soils also lack calcium. Such soils are not typically grass soils, and when used for pasture without attention and treatment, the pasture soon "runs out". Continued pasturing without replacing any of the plant food elements, even on good soil, eventually lowers the fertility to a level where good pasture plants cannot survive. A coarse, rather sparse vegetation takes their place as a first step in reforestation. But even without pasturing, reforestation takes place slowly. Pasturing during this period retards forest reproduction, and usually results in an inferior stand of timber. Much of this decline in the less favored areas has been balanced by expansion in the areas with better soils or more accessible markets. The present distribution of the dairy industry is indicated in New Hampshire Station Circular 53, "Type of Farming Areas in New Hampshire".

If a dairy industry is to be maintained in this state, serious attention must be given to pastures in regard to their maintenance and improvement. Of the 960,876 acres* of so-called pasture land only 78,604 acres* are plowable. Some of this tillable area, although plowable, is too light to make good permanent pasture. Some of the "other pasture", 205,986 acres,* is also unsuited for pasture purposes. It is too rocky, too sandy, too steep, or otherwise unfitted for satisfactory permanent pasture.

If the 78,604 acres of plowable pasture and the 205,986 acres of "other pasture", or such parts as would warrant, were improved, most of the 676,286 acres of woodland pasture could be fenced out without materially lessening pasture production.

As it is, pasture needs are being supplied in several less satisfactory ways: summer feeding of hay and silage, green feed, annual pastures, rowen pasturing, and use of considerable quantities of commercial feeding stuffs. Some part of this supplementary feeding program will probably always be necessary on many farms, but attempts should be made to provide as much of the summer feed from permanent pasture as is economically possible.

Rowen pasture on the farms studied furnished five per cent of the pasture feed. It is doubtful if more than three per cent should be so supplied, confined almost entirely to pasture on areas designated for plowing for the next year's tillage. A certain per cent of annual pasture is desirable on farms where the pasture soils are too light to maintain good permanent pasture without occasional plowing. Some supplemental green feed is needed primarily in the form of grass or corn silage for very dry seasons, probably to the extent of about two to three per cent of the pasture needs. There is some opportunity, as crop production improves under the conservation program, to release some of the less suitable crop land for permanent pasture purposes. However, with a purchase of some 1,422 tons of hay on the

*Census 1935

farms studied, there seems to be little opportunity for using much hay land for pasture.

Including all these, there is still need for more pasture area than will be provided by the plowable pasture and the suitable open "other pasture".

If we assume that all of the 78,604 acres is responsive to treatment, this area might well provide two-fifths of the permanent pasture needs. Data obtained by survey indicate that only 80 per cent of this is suitable for improvement, so that this area would provide only 32 per cent of the permanent pasture needs.

These same data indicate that about 60 per cent of the "other pasture" is suitable for improvement and would provide good permanent pasture. But only about 10 per cent of this area is at present open and in condition to improve by fertilization alone. The rest requires the removal of varying amounts of brush before fertilizer is applied.

Provided we are to maintain our dairy industry at its present level, our pasture needs would therefore require the removal of brush from between 20,000 and 25,000 acres, followed by further improvement, together with improvement of some 60,000 acres more of the 205,986 acres of "other pasture" which is still free from brush.

All these improvements should provide about 196,510 acres of open permanent pasture, the equivalent of about one and one-half to one and three-quarters acres per pasture animal unit.

At the time of the survey only 3.5 per cent of the open pasture had been top-dressed, about 1.6 per cent had been plowed and reseeded, and about 1.1 per cent had been cleared of brush; or 759 acres had been improved out of 12,150 acres of open pasture. These improved areas are on the better farms and represent somewhat greater improvement than would be shown by all farms.

Summer Grain Feeding

For most of the state the improved pasture fills a very small part of the pasture needs. This small area gets more severe pasturing than the rest of the pasture and produces less than if grazing were controlled. Because of its small size it shows little influence on changing the cost of milk production. Whether such pasture improvement is done on the better farms, or is done to provide better feed for better cows, is not possible to state. It is true that on farms where some pasture improvement work has been done summer grain feeding is heavier than on farms where no pasture improvement work has occurred.

Pasture Season

The average length of the pasture season for the state is about 145 days, varying from 130 days to 170 days depending largely upon the practice of fall feeding on hay land.

Of this total period, permanent pasture furnished about 105 days of full feed, rowen 13 days, green feed 14 days, silage 2 days, and hay 11 days. (See Table II.)

Table I. Amount of grain fed dairy cows on 256 New Hampshire farms, 1935

County	On Farms with Some Pasture Improved			On Farms with No Pasture Improved		
	Cattle Units	Grain per Cow		Cattle Units	Grain per cow	
		Total	Summer		Total	Summer
		Pounds	Pounds		Pounds	Pounds
Coos	292 0	1777	397.0	570.5	1152	182.0
Grafton	250.5	1719	368.5	355.5	1415	240.5
Sullivan	88.5	1360	350.0	178.5	1525	386 0
Cheshire	94 0	2114	720.0	176 0	1025	389 0
Carroll	37 0	1407	355.0	11 5	750	280 0
Belknap	129 5	2360	738.0	33 0	1354	380 0
Strafford	236 5	2070	651.0	138.5	1720	580 0
Merrimack	197.5	1755	662.0	90.5	2275	748 0
Rockingham	535.0	2290	671.0	313.0	1950	598 0
Hillsboro	298.5	2505	772.0	328.0	2090	590 0
Total	2159 0	19357	5684.5	2195.0	15256	4373 5
Average		1935.7	568.5		1525.6	437 4

Table II. Pasture season on 256 New Hampshire dairy farms, 1935

County	Cows in Pasture	Days Pasture Season	Days Feed Furnished By				
			Permanent Pasture	Hay	Rowen	Green Feed	Silage
Coos	1003.5	139.9	116.4	3.3	14.3	5.9	...
Grafton	705.5	139.6	108 9	4.7	15.2	9.7	1.1
Sullivan	279.0	142.9	110.6	6.0	12 6	13.7	..
Cheshire	333.0	150.0	112.1	11.9	17 2	8.8	...
Carroll	61.5	130.9	95.1	5.8	7.4	22.6	...
Belknap	242.0	169.2	111.6	21.3	21 3	11.2	3 8
Strafford	370 0	144.5	104 7	13.8	13 2	10 8	2.0
Merrimack	309 5	158.0	112.6	11.5	10.4	19.7	3.8
Rockingham	900.0	140.9	94.0	12.2	11.1	20.0	3.6
Hillsboro	666.0	142.2	82.1	19.3	15.3	22.4	3.1
Total or Average	4870.0	144.3	104 8	10.8	13.2	13.7	1.8
Per Cent		100.0	72 6	7.4	9 1	9 4	1 2

Green Feeding on Pasture

As with grain, somewhat more green feed is given cows on pasture on farms where some pasture improvement work was done. It is also fed somewhat more frequently on farms without silage. Apparently silage takes the place of some summer green feed. (See Table III.)

There is no standard green feed, although Hungarian millet is probably most frequently used because it is easy to grow, the seed is cheap, and it grows in late summer when most needed. Soybeans, Japanese millet, oats, rye, wheat, sweet corn, and some second crop

Table III. Amount of green feeding on pasture of 256 New Hampshire farms surveyed in 1935

County	On Farms with Some Pasture Improved				On Farms with No Pasture Improved			
	No. of Farms	Total No. of Cows	Total Acres Silage	Total Acres Green Feed	No. of Farms	Total No. of Cows	Total Acres Silage	Total Acres Green Feed
Coos	12	292.0	26.5	17.25	28	700.5	33.8	6.8
Grafton	13	360.5	54.5	3.75	19	388.5	50.0	13.75
Sullivan	5	111.0	20.0	3.0	12	214.5	45.0	9.75
Cheshire	7	137.0	21.0	..	11	192.0	51.5	1.5
Carroll	2	37.0	3.0	..	2	24.5	..	..
Belknap	8	158.5	34.0	8.25	7	73.5	13.0	.75
Strafford	14	236.5	34.5	17.25	10	153.0	19.0	.12
Merrimack	9	156.0	41.5	9.75	11	140.0	19.25	4.75
Rockingham	29	568.0	137.0	20.5	20	335.0	65.0	7.5
Hillsboro	17	319.5	80.5	17.25	19	328.0	55.5	14.0
Total	116	2376.0	452.5	97.00	139	2549.5	352.05	58.92
Per Farm		20.5	3.9	.8		18.3	2.5	.4
Per Cow			.19	.04			.13	.023
Pounds per Cow			4180.0	800.0			2590.0	368.0

clover are used. Most of these may also be used for annual pasture, or grass silage.

Annual pasture was not separated from other green feeding. All kinds of green feeding provided 13.7 days or 9.4 per cent of the total pasture feeding period.

Rowen Pasture

There are two usual periods for pasturing rowen. The first is after haying, as soon as growth starts, and the second occurs usually in late September and October. The earlier pasturing is usually on fields to be plowed for cropping the next year. The October pasturing is more generally on all hay land, is not as close as the earlier grazing, and in Coos county particularly, accounts for a second seasonal increase in milk production, which is not, however, as large as the May-June increase. This second increase is smaller because herbage is less nutritious after frosting and because the season of freshening of the largest percentage of the herd is in the spring.

The total of rowen pasturing by counties accounted for 13.2 days or 9.1 per cent of the total pasture.

Hay and Silage

The lack of pasture or of green feed grown for pasture supplement has to be made up by feeding hay, silage, and grain. Of the total feed during the pasture season, hay provided the equivalent of 10.8 days of pasture or 7.4 per cent of the total, while silage provided

1.8 days or 1.2 per cent of the total pasture season roughage. At the time of the survey, most of this was surplus corn silage. The increase in grass silage has provided another succulent summer feed when pasture is lacking. It can serve two purposes, to get a better quality roughage in difficult early summer haying weather, and to provide an excellent and different summer pasture supplement.

The need for somewhat more uniform production nearer the market requires that dairymen in the southern counties with usually poorer pastures, give greater emphasis to pasture substitutes.

There is no satisfactory measure of the effect of pasture on grain saving. Nor is it possible from these records to show the importance of uniform pasture production on milk yield when cows are brought in from pasture or fall feed and placed on full barn feeding. Certain data indicate that this change from poor pasture to poor dry feed or from good pasture to poor dry feed results in a slump in milk production that cannot be overcome by economical winter grain feeding. Pasturing rowen also reduces the amount that can be cut for hay and therefore the amount of high quality roughage available for barn feeding either when cows first come off pasture or in the late winter. The shift from good pasturage with little or no grain to some grain and hay that is none too good does not maintain pro-

Table IV. New Hampshire farms of the 256 in the survey, 1935, using pasture management practices

County	Total number farms	Number farms practicing alternate grazing	Number farms rotating pasture on cropland	Number farms using night pasture
Belknap	15	5	7	6
Carroll	4	2	0	2
Cheshire	18	3	3	7
Coos	40	7	0	37
Grafton	32	14	9	19
Hillsboro	38	12	3	7
Merrimack	21	10	3	3
Rockingham	49	25	3	21
Strafford	24	13	2	7
Sullivan	15	6	1	7
Total	256	97	31	116

duction. It is also true that spring freshening and production of a flush of milk on early summer pasture is not conducive to maintaining good production on poor late pasture and dry winter feed. It is apparent, then, that good pasture is not entirely a matter of saving grain during only the pasture season, but during the barn feeding period as well.

Hayland Conversion into Pasture

If roughage-producing cropland were growing the optimum amount, a small area of hayland now growing rather indifferent hay and unsuitable in other respects for retention as regular tillage land could be converted to pasture.

A dairy cow requires about 3.5 tons of good quality hay per year when no silage is fed. Hay yields over a period of years should average at least 1.75 tons per acre. This would require a maximum of about 2 acres of hay land per animal unit. Data for the 256 farms surveyed show about 1.68 acres, a yield of 1.36 tons per acre and about .28 tons of purchased hay per cow. The balance of the roughage is obtained from silage or its equivalent.

These data seem to indicate that on the larger farms at least this method of obtaining suitable pasture offers little opportunity. However, on farms where such land is available and present yields of hay are low, improved yields of hay would permit such transfer, and would reduce the cost of obtaining a more nearly adequate supply of pasture. Otherwise improvement must occur by fertilization of the open permanent pasture, and by clearing and fertilizing the better brushy pasture.

Annual Pastures

On certain lighter soils where permanent pastures would be difficult or expensive to maintain, annual pasture crops may be substituted. Such annual pasture crops used as nurse crops for hay or pasture seeding are of particular value, since both experimental and practical experience* have shown that a superior stand of hay or pasture usually resulted.

Pasture Production

Pasture area per cow, depending on condition of pasture and percentage of wooded and rocky land, is quite variable, from as little as 4.3 acres in Rockingham county to 9 acres per cow in Sullivan county. The average for the state for the farms surveyed is 5.5 acres per cow. Yet this pasture in its present condition is inadequate. A great deal of even the so-called open pasture has some growth other than good pasture herbage. It includes certain amounts of pasture incapable of economic improvement, or in some cases of any improvement. The open area varies from 1.4 acres to 3.8 acres per cow, averaging 2.3 acres. The total area of pasture supplies only 104.8 days of pasture or 73 per cent of the total roughage used during the pasture season of 144 days. With some shift to later summer and early fall and winter production more pasture than this would be required.

During the summer pasture period the farmers of Coos county fed less grain per cow than did farmers in any other area. The low price for milk makes it necessary to obtain as much as possible of the year's milk production from pasture. Because of this dependence on pasture, slumps in late summer milk production are usually greater than elsewhere in the state.

Pasture Management

Night pasture

Nearly all farms have stock on pasture day and night, but only about half of them pasture milk cows at night. Night pasture is us-

*Report of Department of Agronomy demonstrations.

ually a small area near the buildings, and on some farms is so small as to be of little value except as night exercise ground. Where pasture even for milk cows is limited, many farmers keep the cattle in the barn at night.

On some farms there is no separate smaller night pasture and the labor involved in getting cows in the morning from the large day pasture is too great. Some farmers feel that insects disturb the cows less in the barn. On some farms the need for manure is a minor reason for night stabling. Several farmers feel that it is as good if not better to stable and barn-feed cows than to turn them out into a too scant pasture. Only 116 farms out of 256 have night pasture.

Alternate grazing

Alternate grazing, sometimes more or less irregular, is about as common as night pasturing, for 97 out of 256 report its use. The use of rotated pastures, that is using crop fields as pasture one or more years of the rotation period, is really just beginning to be important as a means of getting more and better pasture. This method can be used only where crop land is sufficient to provide both hay and some pasture. Alternate grazing still further increases the production from permanent pasture.

Data indicate that herbage is of better quality and there is a more abundant supply of good pasture grasses and clovers where alternate grazing is practiced. It is a question whether the alternate grazing produces better pastures or whether the practice of alternate grazing can be followed more successfully on the better pastures.

Fall Feeding

Summer and fall pasturing of regular hay fields is one of the commonest means of providing feed for dairy cows during the pasture shortage. This practice is to be recommended for fields to be plowed in the fall or the following spring for cultivated crops. Fields that are to be retained in hay should not be pastured closely, as pasturing may seriously affect yields of hay in succeeding seasons.

Table V. Soil fertility ratings on rotated and permanent pastures, 256 New Hampshire farms, 1935

County	Soil rating on rotated pastures	Soil rating on permanent pastures
Belknap	3.9	3.3
Carroll	4.0	3.3
Cheshire	3.6	3.2
Coos	4.0	3.8
Grafton	3.9	3.7
Hillsboro	3.2	3.0
Merrimack	3.8	3.4
Rockingham	3.4	3.3
Strafford	3.1	2.3
Sullivan	4.0	3.5
Average	3.6	3.4

Yields on experimental pasture plots indicate that regularly fertilized permanent pasture produces as well as rotated pasture. Through the use of lime and superphosphate, and potash when necessary, quality and quantity of pasture production on permanent pastures may be superior to that from the less suitable pasture plants on rotated pastures. Typical pasture plants are rather slow in establishing themselves, so that most of the herbage on rotated pastures is composed of hay, rather than pasture plants, and is somewhat less suitable for pasturing purposes. Soils were rated from 1 to 5 on their hay-producing capacity in a series 1-2-3-4-5, in which 1 is a poor hay soil, and 5 is a good hay soil.

Data indicate that soils on rotated pastures are somewhat more productive than on permanent pastures. This better soil condition is partly due to better management of hay land, and partly to the better soil-making materials from which these soils are derived.

Pasture Improvement

Fertilization

Pasture is one of the two crops that are frequently assumed to grow without any attention. Very little improvement work has been done on pasture, even up to the last year of conservation work.

Top-dressing has been very limited. Two factors have tended to hold down the use of nitrogen: its cost, and the fact that it provides most forage at the period when there is already an abundance. The use of fertilizers on crop land has given more evident returns than their use on pasture.

The presence of much brush has discouraged many farmers from applying fertilizer before removal of the brush, and its removal seemed too expensive and impermanent. The opportunity to obtain the use of crop or pasture land on adjacent farms no longer operated as farms has delayed the need for improvement of the home pasture; and, as in many other fields of effort, the more distant pastures appeared greener.

The 346.25 acres shown in table VI represent only 4.8 acres of pasture fertilized per farm or only 3 per cent of the total of 11,403

Table VI. Pasture fertilizers most commonly used on farms surveyed, 1935

County	No. farms	Acres	Fertilizer used
Belknap	3	6	Nitrophoska, 8-16-16, manure
Carroll	—	—	
Cheshire	5	49	Manure, 7-6-6, cyanamid
Coos	7	25.5	Superphosphate, 8-16-14, manure
Grafton	8	28.75	Superphosphate, 8-16-14, manure
Hillsboro	14	108.5	Superphosphate, 8-16-14, manure
Merrimack	6	37	Superphosphate, 8-16-14, manure, cyanamid
Rockingham	21	51.5	Superphosphate, 8-16-14, manure, cyanamid
Strafford	6	34.5	8-16-16 manure, $NaNO_3$
Sullivan	2	5.5	10-20-20, manure
Totals	72	346.25	

acres of open pasture on the farms included in this study. This is probably more than would be found on most farms since the farms studied represent somewhat larger than average dairy farms for New Hampshire, and this area represents the total treated over a five-year period.

Practically no lime was used on permanent pasture. A small amount was used on plowed and reseeded pastures.

Plowing and seeding

A still smaller area than that fertilized on the farms included in the survey has been plowed and reseeded. Such treatment is more expensive and where the pasture sod is reasonably good is frequently

Table VII. Acres of pasture plowed and seeded on 50 of the New Hampshire farms in survey, 1935

County	No. farms	Acres
Belknap	4	13.5
Carroll	7	2.0
Cheshire	3	16.0
Coos	3	100
Grafton	2	6.5
Hillsboro	6	20.0
Merrimack	2	8.5
Rockingham	14	58.5
Strafford	7	36.0
Sullivan	2	55.0
Total	50	226.0
Acres seeded per farm		4.5

no more effective than top-dressing. On the lighter soils plowing to make it possible to incorporate organic matter in the soil may be necessary to maintain good pasture production. It is, nevertheless, an expensive way to improve pasture, and can be done on only a relatively small area of permanent pasture.

This area, smaller in total but slightly larger per farm than that improved by fertilization, has less effect than fertilized pasture in reducing costs of milk production.

An average of 4.5 acres of seeded pasture per farm will not have much influence on reducing summer feed costs, since improvement in pasture production often means more cows for the increased pasture rather than more pasture for the same number of cows.

Brush removal

Brush removal alone as a means of improving pasture has not been particularly successful. It has usually resulted in temporary improvement. As stated earlier, one reason why brush is present is because it includes plants that will grow on soil of the low fertility level found in many of our permanent pastures. Brush removal frequently makes way for a form of brush or other pasture growth poorer or more difficult to eradicate than the original brush growth. Sweet fern, low bush blueberry, and sheep laurel are three such

forms, coming in where other and larger growing brush has been removed.

Some of the acreage in Table VIII represents land cleared of brush some time after timber and wood have been cut. Such removal adds less to pasture production than is obtained by top-dressing or re-seeding. None of these three methods have been carried far enough, either as a single operation, or in combination to show significant influence on total pasture production.

Other pasture improvement practices

Pastures in New Hampshire have gradually declined in productivity. As productivity declined the better grasses and clovers were forced out and poorer grasses, weeds, and shrubs able to grow at low levels of fertility came in. These persisted because they were not subject to grazing. On some soils these "poverty" plants became prominent in as short a time as five years. On other soils the change took longer. But such a change occurred on even the best of soils where no attempt was made to retain the good pasture plants by maintaining soil fertility.

Under continued grazing the change from good to poor herbage took place more rapidly, although more good herbage remained for a longer period on the better soils, and only unpalatable brush persisted under grazing.

Results from pasture improvement

A few farms have carried on one or more improvement practices and show increased livestock production.

If we measure pasture improvement by carrying capacity, certain farms show marked change. A selection of thirteen farms (Table IX provides data to show what methods are followed and what can be done to maintain or increase carrying capacity of pastures and crop land. On these farms, carrying capacity was increased in ten years from 213 cows to 283 cows.

No additional land or pasture was hired. With a total of 1,552 acres of pasture, nearly 50 per cent open, 4.2 per cent was fertilized (8.7

Table VIII. Acres of pasture brush removed on 55 of the 256 New Hampshire farms in the survey, 1935

County	No. farms	Acres
Belknap	4	6.5
Carroll	—	—
Cheshire	—	—
Coos	8	28.0
Grafton	6	18.0
Hillsboro	12	23.5
Merrimack	3	3.5
Rockingham	9	23.25
Strafford	12	28.0
Sullivan	1	3.5
Total	55	134.25
Acres brush removed per farm		2.4

per cent of the open area), 3 per cent was seeded, and 5.8 per cent was cleared. Some crop land, 6 per cent, was turned into pasture. A total of 19 per cent of the open area was variously improved. This area compares with 3.5 per cent of the open area for all farms. Measured in terms of needed pasture the improved area of 298.5 acres on these farms would under normal conditions provide about half of the needed pasture for the 1925 herds. For the larger herds pasture furnished 80.6 per cent of the feed as compared with 75.5 per cent furnished by pasture on all farms. The improved pasture has, therefore, not only increased carrying capacity by 32.8 per cent but provided 6.7 per cent more pasture for the increased size of herds, or, on the basis of the original number of cows, would have provided 113.2 per cent of the roughage needed during the pasture season. In other words, these farms could have reduced their pasture area by 33.3 per cent and still have maintained their original herds in as good condition as before.

Table IX. Pasture improvement results on 13 N. H. farms during ten years, 1925-1935

No. farms	13
No. cows or cattle units (1925)	213
No. cows or cattle units (1935)	283
Total acres pasture	1,552
Acres open pasture	760
Acres open pasture fertilized	66.25
Acres open pasture seeded	47.50
Acres pasture cleared	90.50
Acres crop land diverted to pasture	94.25
Total acres increased pasture	184.75
Total improved area	298.50
Improved area per farm	22.96
Improved area per cow	1.05

It must be remembered that this is the total improvement made over a period of ten years. Most of the brush-cleared land has had no other treatment. Some of the fertilized and seeded area has been treated but once. A complete pasture improvement program on these farms would have meant even greater carrying capacity than at present. The improved area is about an acre per cow. Only that cleared and taken out of crop land really means any addition to the area of open pasture, represented by the 760 acres shown at the end of the 10-year period, 1935.

Experimental Plots

The first step in a pasture improvement program is to fertilize the good open pasture land. The second is to utilize the unneeded and poorer hayland for pasture. The third is to plow and reseed areas too poor to warrant fertilizing without reseeding.

Since all of these practices would still leave the dairy industry with less pasture than is needed, removal of brush and fertilization of some of the better non-plowable permanent pasture seem to be the most satisfactory method of obtaining the additional necessary pasture.

No complete experimental evidence indicates the cost or proper methods of removal of the various kinds of brush and the effects of various treatments on later pasture herbage. Connecticut (Storrs) Experiment station demonstrated what could be done on an old pasture almost completely overgrown with gray birch, by removing the brush and trees, and fertilizing. Kansas Experiment station has determined the best season for removal of brush characteristic of that area. West Virginia has studied herbage change under certain pasture conditions.

To study these factors under New Hampshire conditions was desirable. From the analysis of the pasture survey data three methods of brush removal were followed. The first was pulling. As much of the brush as possible was pulled by hand. Conditions were such that not much brush was pulled with power. On most of the plots the larger brush was cut, the smaller pulled by hand.

The second method employed was cutting. A few large pines were felled with a saw. The rest were cut with axes, while the larger brush and sapling trees were cut with pruning shears. The bush scythe was used on small thick brush and hedge shears on small scattered shrubs.

The third method was burning. A fire gun was used for several reasons. Burning would always be under control, removing the danger of forest fire and avoiding as much as possible the loss of surface organic matter that would result from running burning. Since the principle of burning was to kill the brush by destroying the growing tissue sustained heat was desirable. Not much of the woody part of the brush, however, was destroyed even by this method. On all except burned plots the brush was piled and burned. On a few of the burned plots it was found desirable to cut and burn the brush left standing.

Most of the removal of brush in the past has been done by cutting. Next in importance was burning. Pulling has been so expensive and laborious that only where plowing and reseeding were contemplated has this method been used.

Brush Removal and Control

To obtain the necessary data on brush removal and further pasture improvement a series of plots was laid out; nine in the spring of 1937, including seven of .6 of an acre in area, and two of 1.5 acres in area, and 10 plots in the spring of 1938, all of an acre and a half in area. (Fig. 1.) Plots were laid out on pastures that were too steep or too rocky to be improved by plowing and reseeding, and from which brush would have to be removed before fertilization would be advisable. The nineteen plots were located in nine of the ten counties of the state on a variety of soils, with a great variety of rock and brush conditions. The three methods of brush removal were employed on each of the plots. On the .6 acre plots two different fertilizer treatments were used. On the acre and a half plots 5 different treatments were used so that each method of brush removal would have all the fertilizer treatments. If there was any differ-

ence in the brush control that would be made more or less effective by any of the fertilizer treatments used, it was expected such difference would be apparent either the first year or later. Labor in brush removal varied both with the kind and with the amount of brush.

Data on labor requirements for the three methods are given showing the great variation in labor required, computed on an acre basis. (Table X).

Grazing was permitted on all the plots as an adjunct to brush removal and fertilization in checking regrowth of brush. No seeding was done. On most of the areas enough good grass and clover and other plant growth was present to make reseeding of doubtful value.

The above data (Table X) show the amount of labor required during a three-year period to get practical control of brush. The time spent the second and third year gives an indication of the per cent of control obtained the first year. With pulling, 95.2 per cent of total labor was used the first year; with cutting 92.9 per cent; and with burning 87.6 per cent. There are still certain plots that will require some brush removal this year but the amount is small and the brush is chiefly sweet fern, sheep laurel and blueberry.

The different kinds of brush respond differently to the three methods of removal. Sweet fern is most effectively controlled by pulling. With this shrub, pulling requires less time than burning because the very thick bark is quite resistant to fire, and grazing the area does not help except through breakage from treading by the cattle. Pulling early in the spring will control most of the sweet fern, so that

Table X. Hours labor in removing brush on experimental pasture plots, 1937-1939

	Pull plot	Cut plot	Burn plot
LaCoss	13	14	20
Falconer	39	52	42
Ahern	105	78	54
Atwood	144	94	10
Kingsbury	132	117	117
Savage	46	43	47
Witty	132	95	36
Dearth	74	58	44
O'Dell	76	61	42
Tenney	163	69	84
Cutter	126	101	41
Chaffee	81	50	22
Muzzey	230	57	80
Friend	49	49	19
Garland	94	126	52
Hall	94	94	80
Shaw	127	85	64
Stewart	41	123	102
Potter	163	163	163
	1929	1529	1119
Per acre	101	80	59

Pulling varied from 12 hrs. 55 min. to 229 hrs. 30 min. per acre.
Cutting varied from 13 hrs. 45 min. to 100 hrs. 50 min. per acre.
Burning varied from 10 hrs. to 84 hrs. per acre.

late summer growth and the next season's regrowth are small. Blueberry and sheep laurel are almost impossible to pull, are very tough and hard to cut, and are somewhat resistant to burning.

Burning for two or sometimes three years will be required to satisfactorily control these three shrubs, particularly since none of them is grazed even when fertilized. The advantages of burning, other than the somewhat smaller amount of labor required to con-

Burned brush should be removed.

Plot on Witty farm showing objectionable feature of burning brush without subsequent removal.

trol brush, are that it kills seeds that may have accumulated around the shrub and it checks weed reproduction.

Juniper is easily controlled by burning. It may be pulled with power, but because of its extensive and fibrous root system pulling leaves large bare places with no top soil left, and the several years' accumulation of seed under the branches is scattered broadly in dragging to pile for burning. Burning destroys many of these seeds and effectively kills the plant. It does, however, leave the dead branches to interfere somewhat with grazing. Although cattle will not graze on juniper, usually so few new plants start after burning that grazing is not a necessary part of the control of the shrub.

Gray birch can be readily killed by burning with the fire gun. Trees up to two or two and one-half inches in diameter may be handled in this fashion. The oils in the bark are quite inflammable. The new shoots that start from the root are fairly edible after fertilizing and cattle keep them browsed down, preventing regrowth. Larger birches and rather heavy stands are more easily removed by cutting, and sufficient fuel wood may be obtained to pay for the labor of re-

moval. However, reproduction of pasture herbage is often so slow that it may be questionable to attempt to clear such land for pasture.

Hardhack or steeple bush is usually readily killed by burning, but the new shoots that start from the roots are partially protected by the standing dead canes and some browsing is thus prevented. The canes of hardhack, particularly when dead, are very hard and difficult to cut with a bush scythe, but many of the dead canes break over in a year and are tramped under foot. Pulling early in the spring is quite effective, resulting in about 95 per cent control in one year. The greater palatability because of the fertilizer induces some browsing. Cutting hardhack is usually only about 50 per cent effective the first year.

Meadow sweet, a smooth-leaved spirea, is also difficult to cut and almost impossible to pull. Burning and cutting are the best methods of control. Cutting has one objectionable feature with hardhack and meadow sweet. The clump growth of these two shrubs leaves many sharp stubs when cut, and these sharp stubs are almost as great obstacles to browsing of the new shoots as are the old canes left from burning.

In addition to labor, burning required but little kerosene for the fire gun. This varied from as little as a gallon per acre to as much as eight gallons, depending upon the kind and amount of brush. This cost about 11 cents per gallon.

The character of brush growth is frequently an indication of the quality of soil and of the permanence of pasturage, once established. Sweet fern in solid stand is more usually found on the lighter soils. These soils are less suited for permanent pasture than heavier soils. A solid stand of hardhack is usually found on a relatively good pasture soil. Juniper may be found on a variety of soils, frequently either sandy or ledgy. A mixed stand of hardhack, meadow sweet, sweet fern, sheep laurel, gray birch, juniper, blueberry, some scattered small pine and other shrubs in lesser amount, usually indicates a good pasture soil, retentive of moisture through a long season. The varied brush growth indicates that the soil had been pastured till the level of soil fertility was too low to maintain good pasture herbage. The growth of various kinds of brush is the first step in its return to woodland, but pasturing makes this return to forest very slow.

Soil Treatments

Under continuous pasturing soils finally become highly acid. This is one of the reasons old permanent pastures usually produce so little good pasture herbage. The pH was determined for all the pastures and again for the variously treated plots. The soil samples were taken only to a three-inch depth, since most of the lime and superphosphate applied remains in the upper inch or two of soil. The pH concentration on the various plots is shown in Table XI.

Lime and the various fertilizers were applied at uniform rates on all plots irrespective of amount and kind of herbage and of fertilizer needs. As shown later by soil analysis the nineteen pastures were all lacking in phosphorus and potassium and all but three were too low in calcium to grow red clover. Even in these three pastures the

Table XI. pH content of soils on experimental pasture plots, 1939

	Treatment					
	Lime and super phosphate	Super-phosphate and potash	Nitrate of soda	8-16-16	Lime and 8-16-16	Check
Friend	5.19				5.12	4.92
Cutter	5.00				5.26	4.95
O'Dell	5.44				5.31	5.13
Kingsbury	5.12				4.81	4.78
Ahern	4.84				4.92	4.76
Falconer	5.08				5.33	4.96
LaCoss	5.86				5.43	5.35
Potter	5.00	4.74	4.74	4.50	4.88	4.47
Shaw	4.86	4.86	4.66	4.72	4.72	4.85
Dearth	5.03	5.01	5.09	5.06	5.34	5.10
Witty	5.07	4.80	4.70	4.53	5.09	4.59
Chaffee	5.00	4.72	5.25	5.00	5.21	5.00
Savage	5.00	4.87	4.99	4.97	5.00	5.01
Atwood	5.00	4.60	4.85	4.85	4.90	5.49
Tenney	5.45	5.10	5.42	5.01	5.18	5.10
Stewart	5.80	5.38	5.38	5.11	5.79	5.54
Hall	5.23	5.10	5.05	4.95	5.14	4.94
Muzzey	5.29	4.77	4.72	4.77	5.20	4.72
Garland	5.10	4.88	4.82	4.70	4.94	4.82
	98.36	58.83	59.67	58.17	97.57	94.48
Average	5.18	4.90	4.97	4.85	5.14	4.97

response to lime as measured by the increase in wild white clover was as marked as on those soils showing a greater need for lime.

Because of the small amount of good pasture herbage on these plots at the start of the experiment, response was measured not in weight of herbage, but in control of brush and increase in ground cover and good grasses and clovers.

Herbage composition was determined on the basis of the area available for plant growth as 100 per cent. This does not include the six per cent of total area covered by rock and rock ledge.

The average original stand of good grasses and clovers on the 19 plots was 11 per cent. The poor grasses, primarily poverty, sweet vernal, and broom sedge occupied about 11 per cent of the ground area. Weeds, most of which were inedible or unsuitable for milk production, and moss covered about 22 per cent of the ground area. Brush occupied nearly 51 per cent of the ground area, and about 5 per cent was bare.

The first season's response to clearing and fertilizing was a marked reduction in brush growth, considerable increase in good grasses and clover, an increase in various weeds, little change in amount of poor grasses, and a reduced amount of moss, particularly on the nitrogen plots. Although no ferns or brakes were observable before clearing, these plants came in quite generally during the first year on eight of the nineteen pastures. The real improvement appeared the second year.

The herbage composition is shown in Table XII.

The LaCoss pasture had the least brush, about 14 per cent; good grass, largely bents, occupied about 16 per cent; poor grasses about 22 per cent; and weeds, including moss, covered 42 per cent; with about 6 per cent of the ground bare.

The Stewart pasture had the heaviest stand of brush, an almost pure stand of gray birch with some pine, poplar, juniper, and hardhack. This growth was so heavy that only 3 per cent of the ground cover was grass. About 8 per cent of the area was rock ledge. The brush growth was so heavy that when removed more than half the area was without any vegetation except lichens and moss. Yet this pasture had one of the highest pH concentrations, even on plots not treated with lime.

On the LaCoss pasture, after fertilizing in the spring of 1937, the herbage shifted from 14 per cent to 3 per cent brush; from 16 per cent good grasses to 65 per cent, including approximately 12 per cent of wild white clover; a slight reduction in poor grasses from 9 to 3 per cent; and moss from 25 per cent to 4 per cent.

On the Stewart pasture the brush cover was reduced from about 85 per cent to 11; while good grass increased from 5 per cent to 38; weeds increased from 10 per cent to 43 per cent; while 8 per cent of the area was rock ledge. The lack of good herbage or even weeds made recovery to good pasture herbage much slower than on the LaCoss pasture. The gray birch, however, was practically eliminated by the spring of 1940.

Plot Results

On the basis of method of removal of brush, pulling required the most work and was most effective in preventing regrowth of brush. Pulling required an average of 101 hours per acre. Burning was next most effective and required only about 60 per cent as much

Table XII. Herbage composition of pasture plots in per cent of ground cover

	Herbage								
	Brush		Weeds		Good Grasses		Bare		Rock
	1937-38	1940	1937-38	1940	1937-38	1940	1937-38	1940	
LaCoss	14	3	64	32	16	65	6	0	3
Savage	32	4	57	33	11	63	0	0	9
Falconer	33	4	24	25	18	65	25	6	2
Garland	35	4	54	38	3	56	8	2	8
Ahern	41	6	38	30	17	64	4	0	1
Friend	46	5	50	12	2	50	2	3	3
Cutter	49	1	26	25	25	74	0	0	5
Tenney	49	10	37	37	11	41	3	3	7
O'Dell	52	8	24	14	19	77	5	1	15
Potter	53	4	30	35	1r	49	17	12	0
Hall	55	3	30	53	10	33	5	11	0
Kingsbury	57	16	33	21	10	61	0	2	0
Witty	59	2	31	60	5	26	5	12	5
Chaffee	62	21	10	22	24	54	4	3	10
Muzzey	63	44	27	25	10	31	0	0	5
Stewart	65	3	20	51	5	34	10	12	10
Shaw	66	23	26	21	3	49	5	7	11
Dearth	68	9	25	32	3	53	4	4	8
Average	51	10	33	31	10	54	5	4	6

time. Burning required an average of about 60 hours per acre. Cutting was least effective in controlling brush and required about 80 hours labor per acre. Without cutting, grazing would have been effective only with the brush that is edible.

For a given fertilizer, there is no apparent difference in effectiveness of the three methods of brush removed. The difference is between different fertilizer treatments. With a small percentage of grass present on many of these pastures, response in more grass would be relatively small. The small amount of grass coupled with the acid condition of most of the soils would reduce the response to fertilizers. There was sufficient wild white clover in all the pastures to respond to fertilizer. Under favorable circumstances at the end of the third season the Potter and Friend plots had a wild white clover cover of about 50 per cent. On the Potter, Savage, Muzzey, Garland, Shaw, Dearth, Chaffee, Tenney, and Stewart pastures the lime—superphosphate treatment gave best results in a shift from poor grasses and weeds to good grasses. The Friend, Cutter, O'Dell, Ahern, and LaCoss pasture plots treated with lime and superphosphate gave results as good as or better than plots treated with lime and complete fertilizer. Under circumstances in which the grass and clover coverage is light by reason of poor soils and the shading and crowding by brush, the nitrogen of a complete fertilizer is largely lost. Lime and superphosphate put soil in condition to increase good grass and clover. Only where the sod coverage is reasonably good will nitrogen be needed. Potash apparently is not needed to increase the stand of clover, but may be needed to maintain it once established. Nitrogen was quite effective in killing moss and in stimulating grass, weeds, and brush already present, but was of little value in increasing the amount of clover. From these tests the conclusion may be drawn that for improvement of permanent pastures reclaimed from brush, lime and superphosphate offer the best and most economical initial fertilizer treatment that can be applied, particularly under the conservation program.

Aside from fertilizer, costs for brush clearing with an assumed rate of 40 cents per hour for labor varied from $5.17 to $91.60 per acre for pulling, $5.50 to $40.33 per acre for cutting and $4.00 to $33.60 per acre for labor in burning, plus $.11 to $.88 for oil.

These costs are high, and would be prohibitive if all labor were hired. But much of the work would be done with home labor or other already available labor at such times as would interfere least with other farm work.

To what extent such pasture improvement should be done depends on the need for pasture and the effect it will have on farm organization and income. The data indicate that returns from good pasture are such that labor expenditures up to probably 50 to 60 hours per acre can well be justified. Lime and superphosphate have given as good or better results than other fertilizer treatment, and under the conservation program are obtainable at a cost of less than a dollar per acre. The addition of potash when clover shows in quantity increases the cost only slightly over a dollar per acre. These three materials on cleared, good-soil pasture should make possible

such pasture as will carry one cow on one and one-half acres of pasture for the full pasture season. Savings in fencing and other costs incident to a larger, less productive pasture, and less dependence on costly distant pastures for young stock and dry cows are usually enough to carry the annual cost of fertilizer on improved pasture.

Fencing Costs

One of the high costs for pasture is for fencing and its maintenance. It is common practice in most parts of the state to pasture young stock and dry cows on pasture separate from that for the milking herd. This may be a fenced-off part of the home pasture, pasture on an adjacent farm, or pasture at a distance. About 57 per cent of the young stock is pastured away from home and of this about half is on rented pasture. Supervision of stock is usually included in the rental, the owner of the stock need visit them only occasionally. On distant owned pasture weekly visits are the rule, to salt, note condition of stock, of fences, of pasture, and to bring or take away dry cows or those about to freshen. These pastures, whether hired or owned, rarely receive any attention except to see that fences are tight. Such neglect means less and less carrying capacity, and poorer growth and condition of stock. Dry seasons aggravate this condition and materially hasten the time when the pasture becomes too poor to justify renting.

On the farms surveyed there is sufficient pasture area to furnish most of the pasturage for all the livestock, provided it were improved and placed in its optimum productive capacity and maintained there with proper fertilization and use. Such improvement would permit a reduction of about 35 per cent in area and of about 45 per cent in fencing costs.

Summary and Conclusions

THE available open pasture of New Hampshire farms studied is in such condition that it would furnish only about three-fifths of the total amount of pasture needed for our present livestock. To provide the necessary pasture, about 20,000 to 25,000 acres of brush pasture must be cleared, and this as well as the good present open pasture must be fertilized. This should provide a total of about 196,500 acres of good open pasture.

It seems uneconomical to incurr considerable expense by harvesting crops to feed to dairy cows during the pasture season, instead of improving pastures so that the cows may do their own harvesting.

There are several ways of producing summer green feed, but these are all more expensive than obtaining green stuff from pastures. Rowen furnishes cheap pasturage, but close grazing may injure later hay crops.

On farms with some improved pasture more grain, silage, and green feed were fed than on those farms where no pasture was improved.

Ensiling grass and clover provides a means of avoiding losses from poorly cured hay during wet periods, and furnishes a satisfactory supplement to late summer dry pastures as well.

The average pasture season of 144 days is shorter than would be possible under a complete and satisfactory improved pasture program.

As farmers are already purchasing hay, there is only a limited opportunity to convert the poorer hayland into permanent pasture. Where such land is available, however, it offers an excellent means of obtaining permanent pasture at a lower cost than by clearing brush from land.

The large area of so-called pasture requires unusually heavy expenditures for fencing, both in materials and labor. On many farms the savings in fencing costs on an area of improved pasture much smaller than the present permanent pasture area, would pay the annual fertilizer bill for improved pasture.

The kind of brush present on pastures is an indication of the level of soil fertility. Juniper, sweet fern, sheep laurel, and hardhack among the shrubs, clubmoss, wintergreen, cinquefoil, ladies' tobacco, and yarrow with poverty and sweet vernal grasses grow on soils near the lowest level of fertility.

The kind of brush is also an indication of the potential quality of pasture. Some shrubs such as sweet fern, if in nearly pure stands, indicate in general a light soil not well suited for improvement. A heavy stand of either hardhack or meadow sweet is usually an indication of a soil with a high moisture-holding capacity, with good pasture possibilities when improved.

A mixed stand of brush is usually found on a good pasture soil. It is also an indication of some improvement in soil fertility, or a step up from the juniper level.

Three methods of brush removal were used, pulling, cutting, and burning. Pulling required about 100 hours, cutting about 80 hours, and burning about 60 hours per acre.

Pulling is usually about 95 per cent, cutting about 60 per cent, and burning about 85 per cent effective the first year. With most kinds of brush, all three methods are about equally effective by the beginning of the third year.

Sweet fern, blueberry (low bush), sheep laurel, and blackberries are very persistant. Blueberry and sheep laurel are too difficult to pull and too short or too hard-stemmed to cut. As yet seasonal conditions have been such that twice a year burning could not be practiced as a control for the two shrubs.

Grazing was permitted after brush removal and fertilizing as a necessary part of brush control. The new brush growth, particularly of gray birch, was made more palatable by fertilizer treatment and was browsed by the cattle. There was less browsing on hardhack, meadow sweet, and high bush blueberry, and practically none on sweet fern, sheep laurel or low bush blueberry.

While moss covered a rather high percentage of the ground on these plots, it is not a serious deterrent to pasture improvement. If soil conditions are such that good pasture plants can grow, the moss will soon be crowded out. While nitrate of soda materially reduces the amount of moss, the increase in good pasture herbage is very slow. Improvement comes more quickly with lime, superphosphate, and potash.

Because of the high labor requirement in removing brush, it is desirable to clear a small area each year, probably not more than two to five acres depending on the kind and the amount of brush. The amount of land cleared each year should give, with the area already improved, from 1½ to 1¾ acres of improved pasture per cow by the end of six to ten years.

The pasture improvement program should start with:

1. Improvement of the good permanent pasture areas already free from brush.
2. As hay yields improve, utilization of the poorer, rougher hayland for permanent pasture.
3. Removal of brush from the better soils and treatment with one ton of lime and 200 pounds of 20 per cent superphosphate, or its equivalent per acre. In the second year, application of 150 pounds of muriate of potash will increase and hold the wild white clover.

The fertilizer program should be:

1. One ton lime, 200 pounds superphosphate per acre the first year.
2. One hundred and fifty pounds muriate of potash per acre the second year.
3. Three hundred pounds superphosphate per acre the third year.
4. One hundred fifty pounds muriate of potash per acre the fourth or fifth year.
5. One ton of lime per acre the sixth year.

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